McKinsey & Company

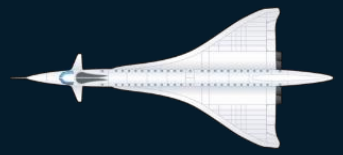
Future of eVTOLs

October 2023

What is “Future Air Mobility”?

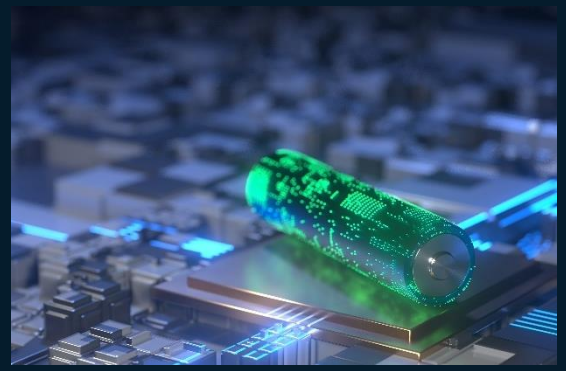
“Future Air Mobility” is a new set of aerospace use cases across human & cargo transport, surveillance, & operations.

eVTOL	New people transport use cases: e.g., highly autonomous VTOL aircrafts flying at lower altitudes – **mainly for Urban Air Mobility**
Sustainable aviation	Retrofit/evolution of existing aircraft architecture with electric or hybrid propulsion, **mainly for regional mobility**
Unmanned AAM	New goods/freight delivery use cases: inter-city delivery by drone, long-haul cargo, and ultimately autonomous people transport
Supersonic & hypersonic flight	futuristic aircraft flying up to 2.5 faster than commercial jets today – aiming at targeted commercial routes



Why is eVTOL "taking off" now?

Technological convergence



Battery energy density has **tripled** in the **last 10 years**

Sustainability

23% of emissions are triggered by transportation

Shared mobility

E-hailing is a **~$150B** global market

Traffic congestion

People in the US spent an average **51 hours** waiting in traffic last year

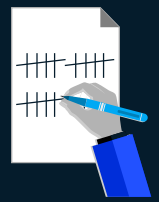
Industry momentum continues into 2023 so far

1

$12.5 billion

Total eVTOL funding, $1.0 billion in 2023

2



10,100

Orders and options placed, representing $31 billion in potential value for eVTOL aircraft

3

70%

Percentage of top 25 OEMs and Suppliers active in Future Air Mobility

4

891

FAM Supply chain deals announced

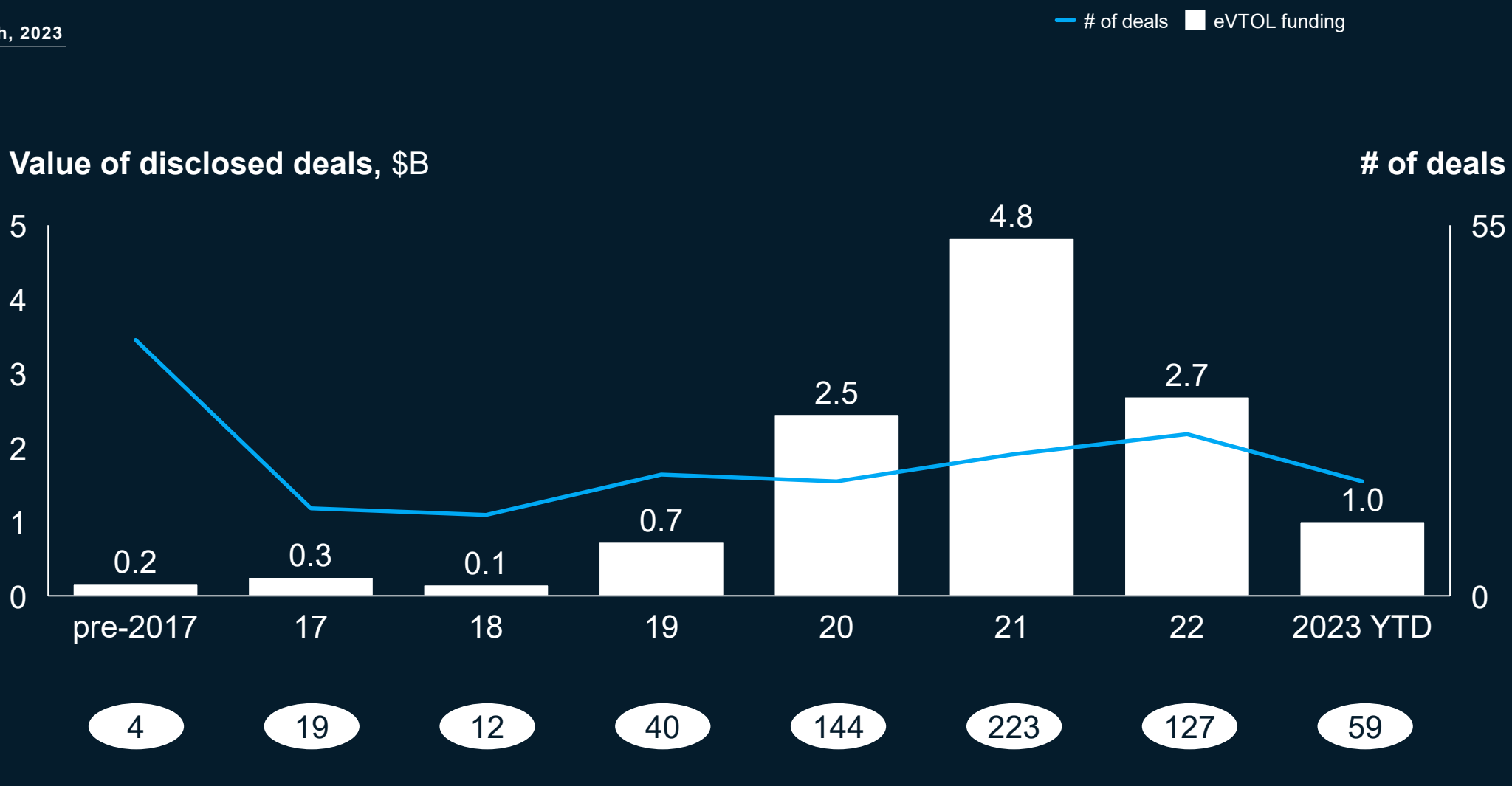
5

8,000 hours

Of test flying eVTOL aircraft

eVTOL funding recorded several large deals in 2021; many companies will need additional cash in next 18-24 months

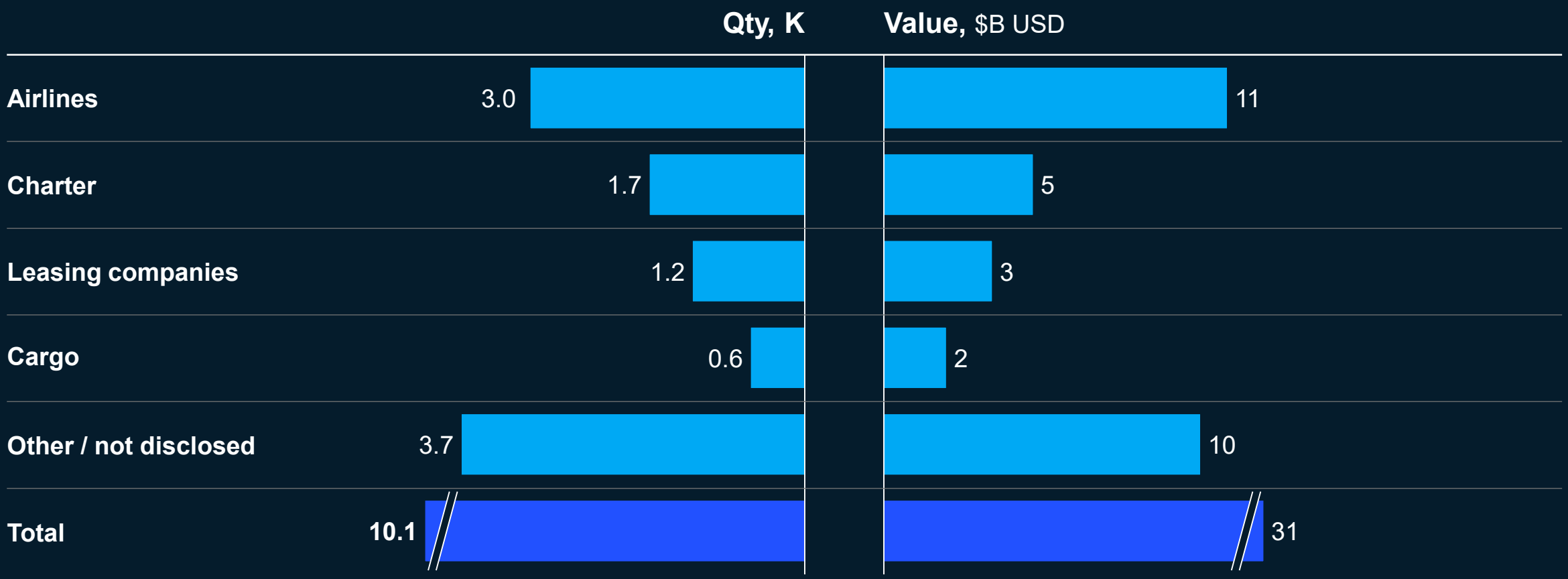
As of September 26th, 2023



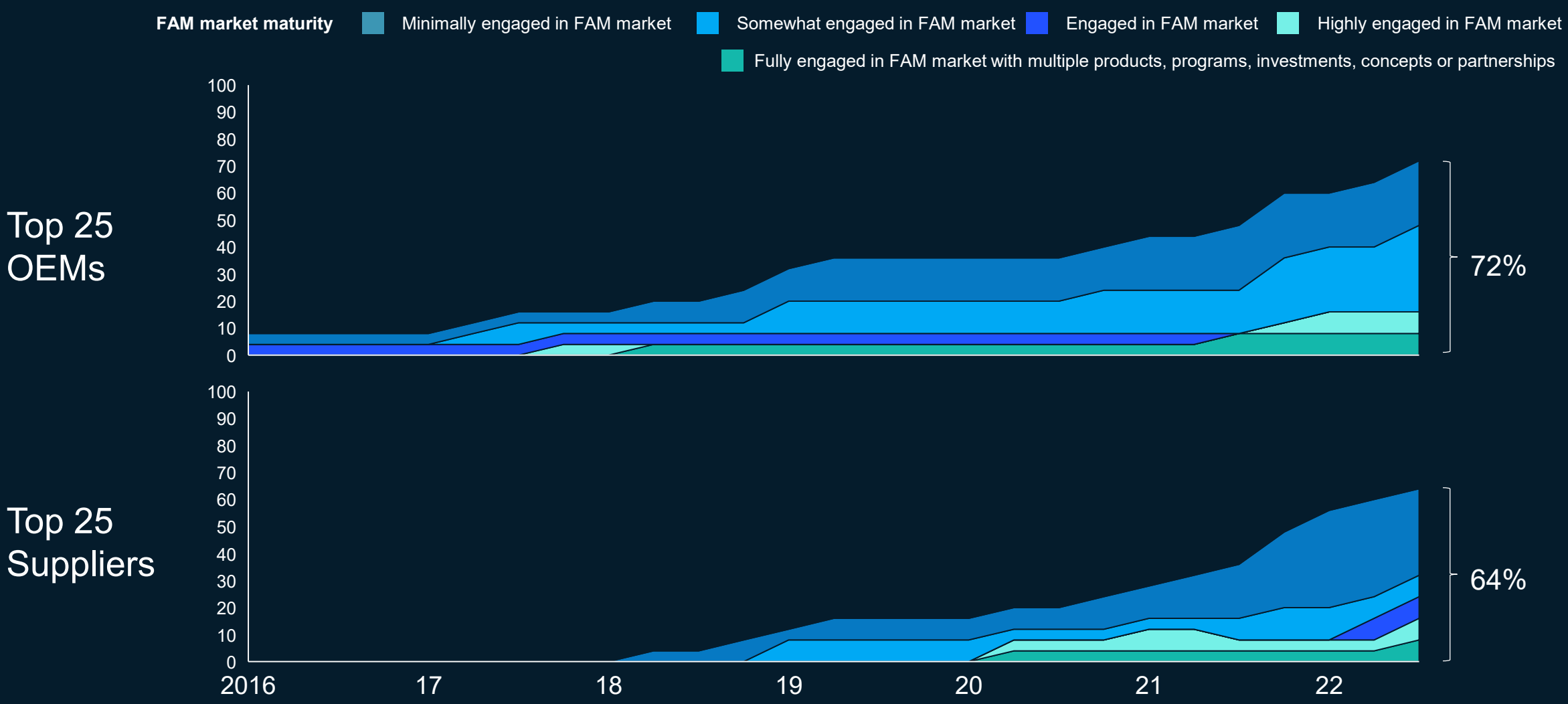
~10,100 orders worth an estimated $31B have been placed for eVTOL aircraft

eVTOL orders by industry segment

As of September 26th, 2023



Incumbents are getting involved



Traditional suppliers are focusing on all aircraft systems while disruptors focus on the powertrain

As of September 26th 2023

Deals announced[1]

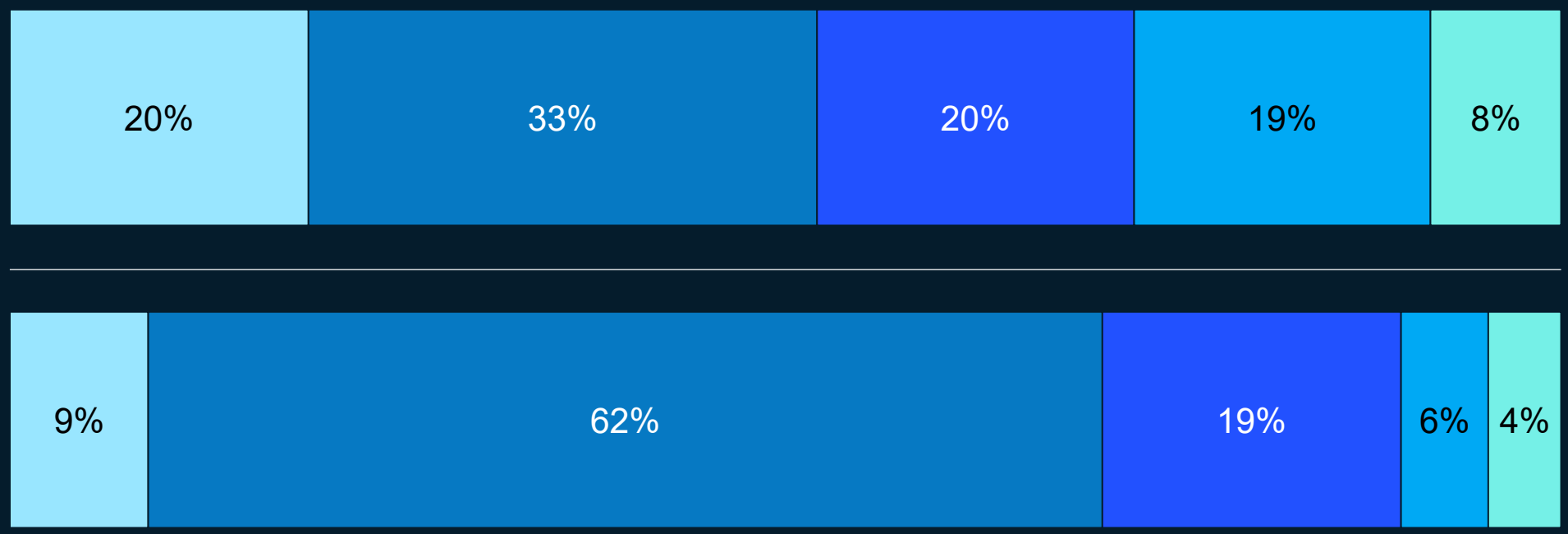
Traditional

676

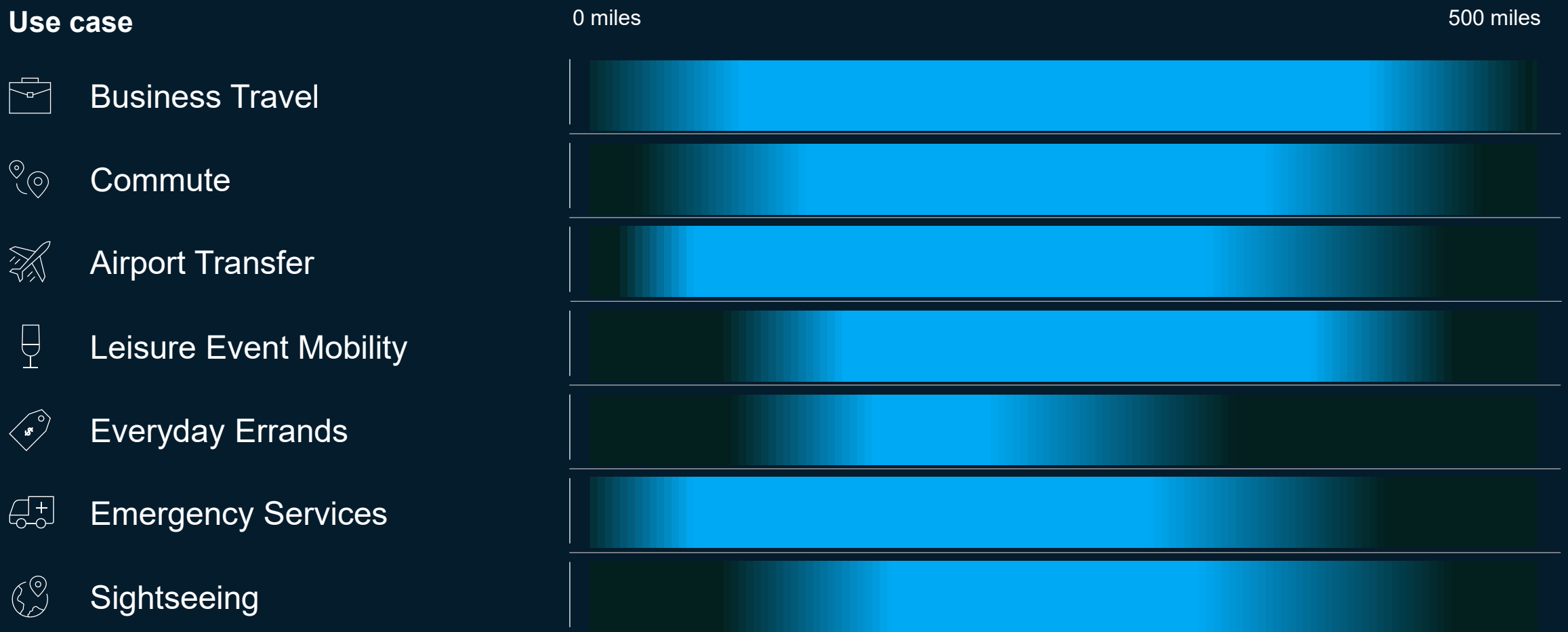
Disruptors

215

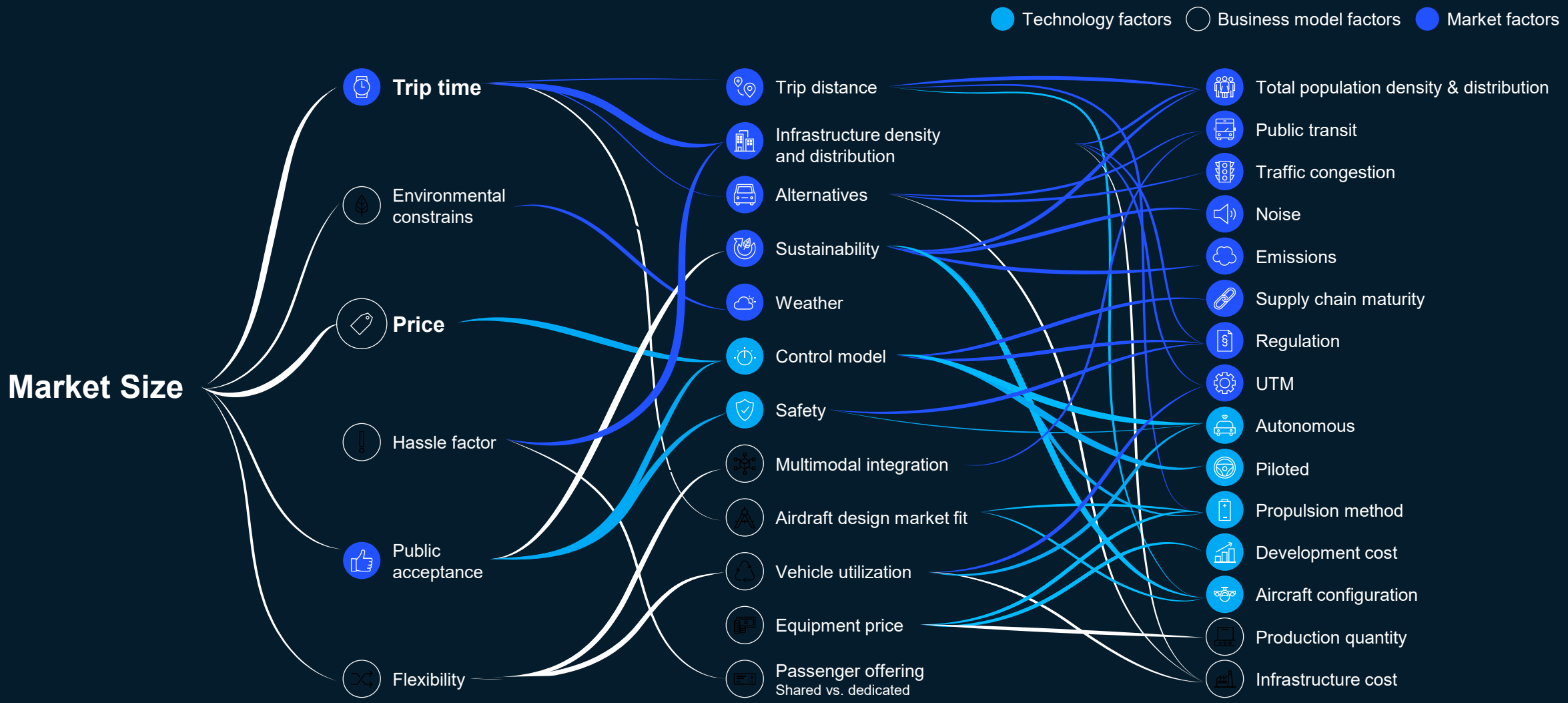
Deals by category



eVTOL fits into seven major use case archetypes distributed across various distance ranges



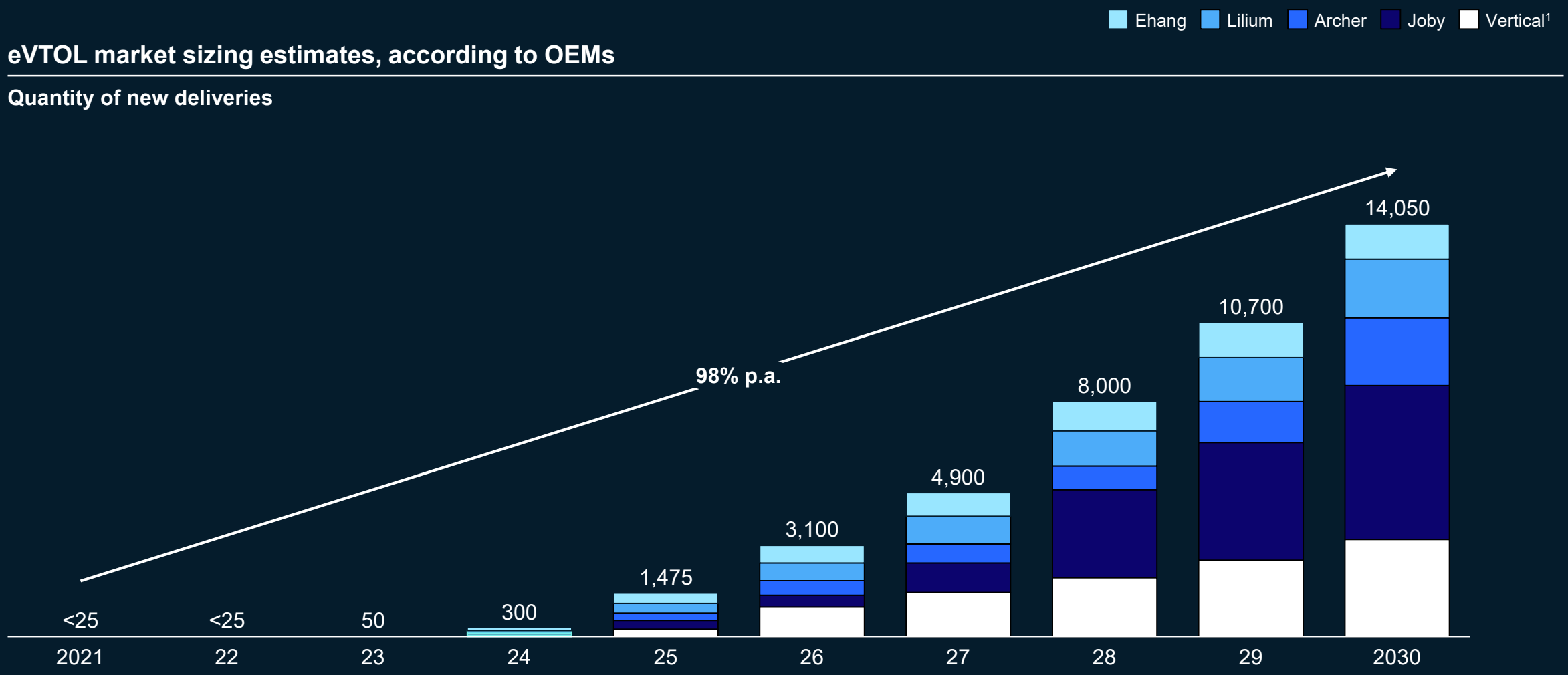
UAM market size depends on several drivers



Publicly traded OEMs disclosed to investors that they plan to delivery 14K units a year by 2030

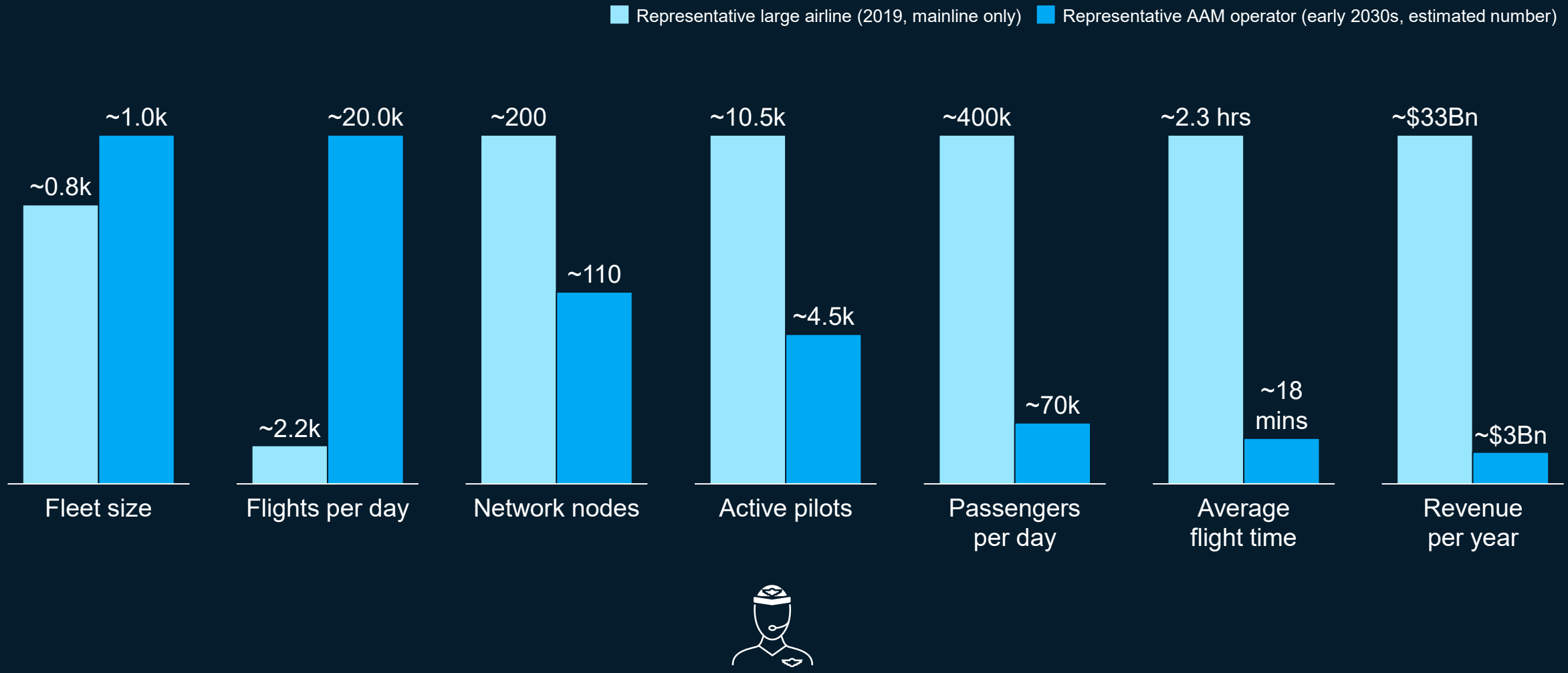
eVTOL market sizing estimates, according to OEMs

Quantity of new deliveries



1. 2030 numbers are estimated based on trend

Passenger eVTOL operators could soon rival the largest airlines in terms of fleet size and flight operations



What will it take to scale up the future and bring it to everyone?

Cost/price

Let's figure out the economics

Customer experience

An operational backbone that enables a seamless experience

Regulation

A regulatory framework that truly enables the industry

Public acceptance

Trust and support from passengers, cities, municipalities

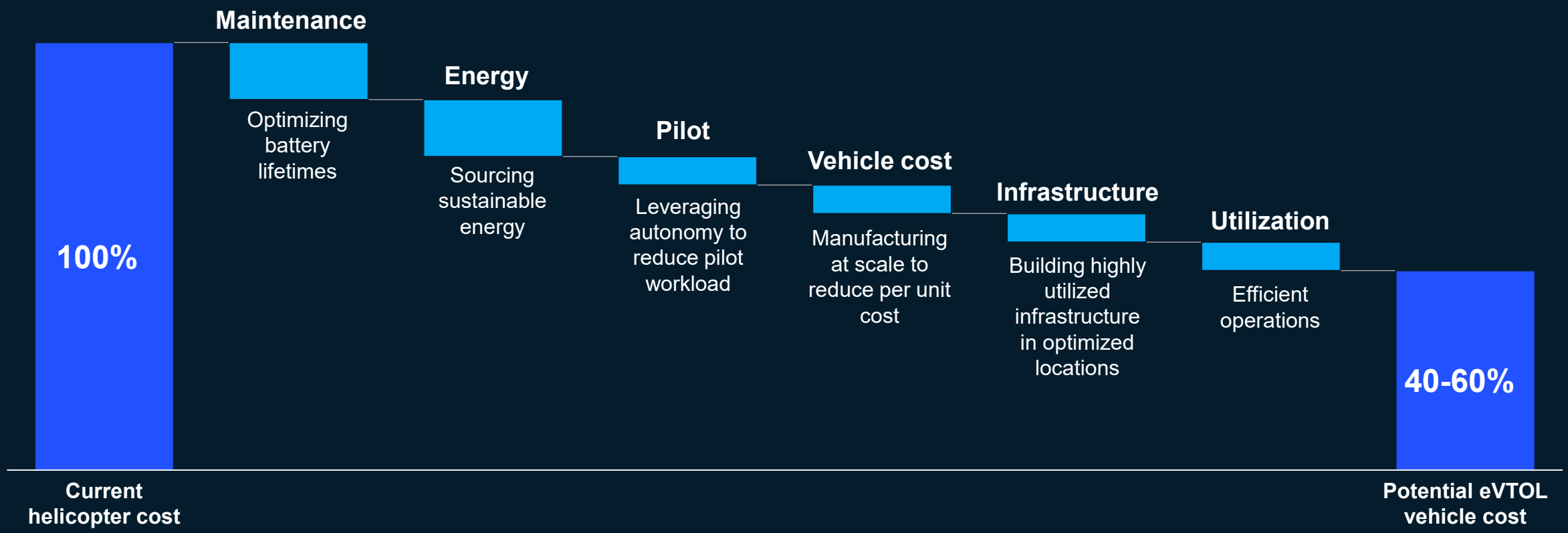
Infrastructure

Vertiports/pads in locations that are convenient and can integrate with multiple transport modes

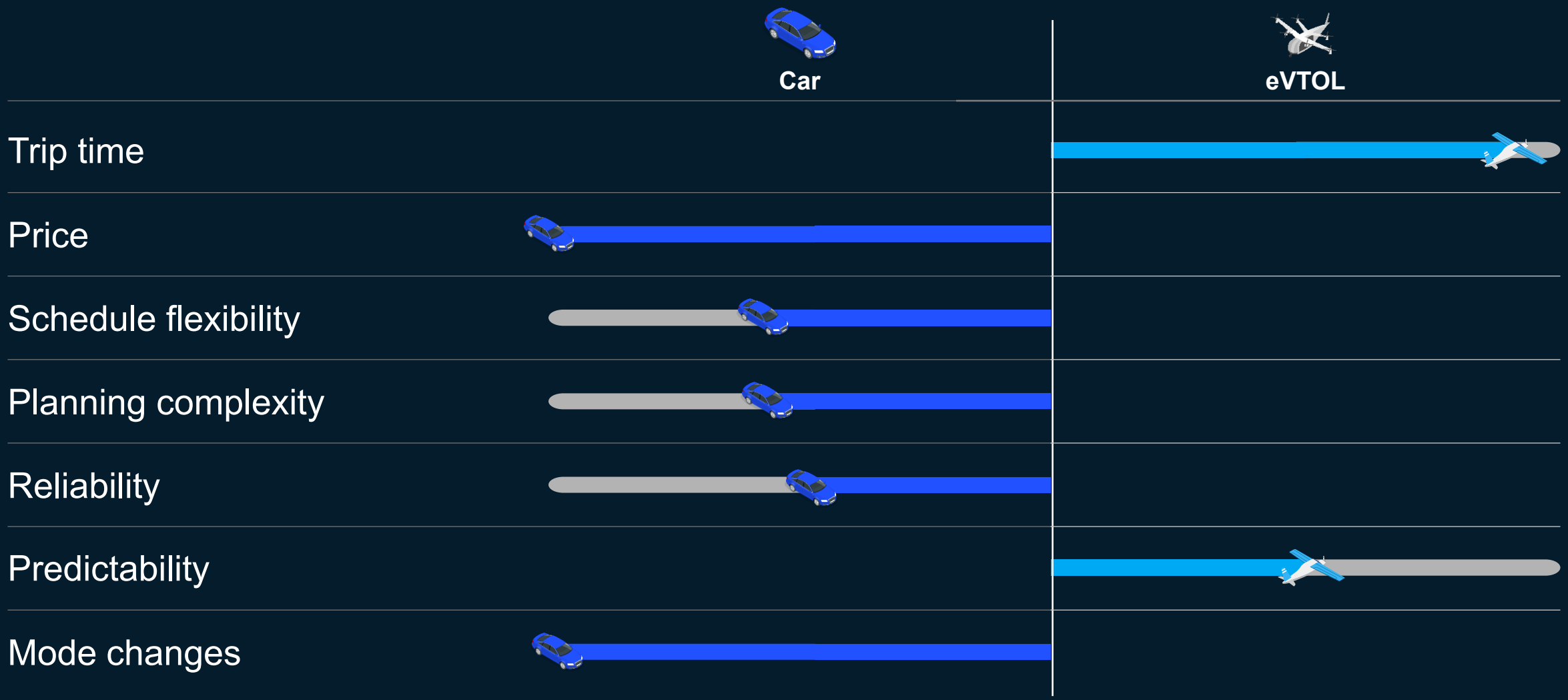
Several factors could reduce eVTOL operating costs down from helicopters today, but each is a unique challenge

Illustrative

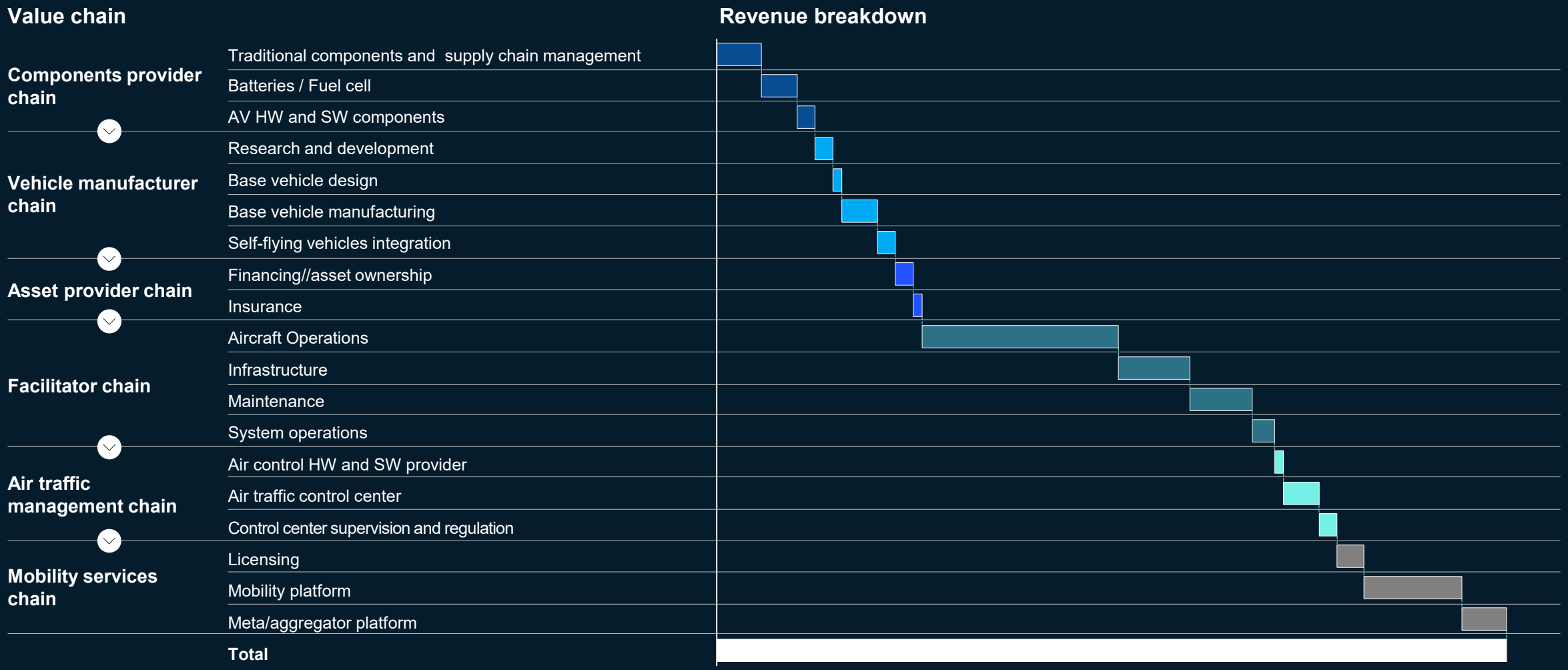
eVTOL vehicle, operating cost per seat-mile, %



eVTOL wins on time – but still loses on other dimensions



The value chain will be complex, and can take many forms, here is an example of what it could look like



Regulations for eVTOL aircraft will need to evolve to ensure industry can certify and operate at scale

Aircraft Type Certification

Airworthiness approval to ensure safety and reliability of a particular aircraft design (type)

Production / Certification & Airworthiness

Inspection and approval to ensure process maturity and product quality at manufacturing facilities and to show that aircraft built is identical to the type that has been certified

Continuing airworthiness & Maintenance, Repair & Overhaul

Keeping the a/c in a condition where it remains airworthy throughout its life as stated in the Type Certificate

Pilot/Operator training & certification

Pilot education and training to ensure mastery of aircraft operation

Airspace & operating rules

Rules and guidelines for operating in the national airspace alongside other air traffic

Infra-structure

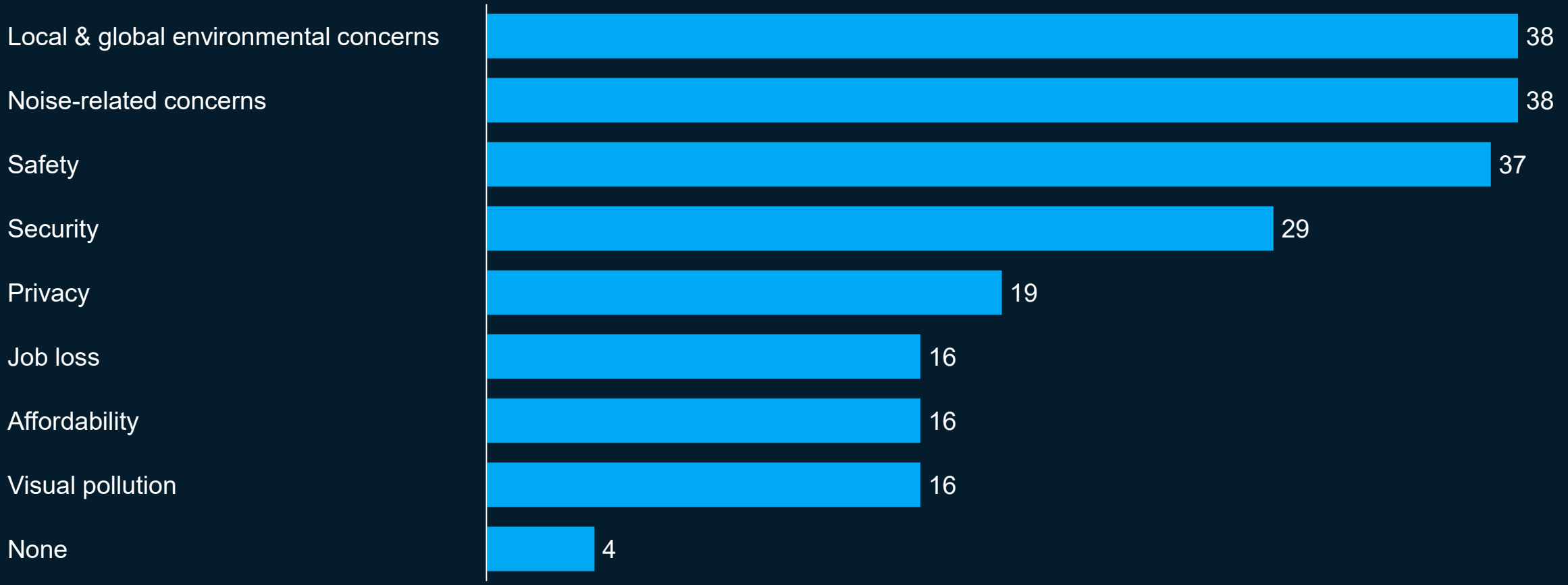
Standards and guidance that ensure infrastructure supplies the right space and services in a safe manner (e.g., structural loading, high speed charging)

Local/State regulation (e.g., noise, environmental impact, privacy, insurance requirements)

Public Acceptance of eVTOL aircraft will require addressing several areas of concern

Concerns regarding eVTOLs ranked by % of respondents ranking in top 3

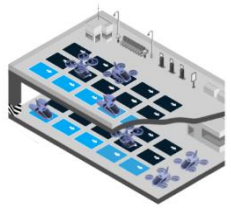
Top ranked concerns



CapEx and OpEx drive roughly equivalent portions of infrastructure cost

OpEx and TCO breakdown[1], Annual $USD

TCO Component	Subcategory	Archetype 1: Vertihub (10 FATOs, 21.0k m²) cost, M USD	Archetype 2: Vertibase (3 FATOs, 5.6k m²) cost, M USD	Archetype 3: Vertipad (1 FATO, 1.8k m²) cost, M USD
CapEx	CapEx depreciation	5.2	1.4	0.4-0.5
OpEx	Rent/land leasing	2.3	0.6	0.2-0.4
	Labor	2.2	0.9	0.1-0.2
	Electricity	0.4-0.5	0.1-0.2	0-0.1
	Connectivity to UTM system	0-0.1	0-0.1	0-0.1
	ATC fees	0.3-0.5	0.1-0.2	0-0.1
	Total OpEx	5.2	1.7	0.3-0.5
Total (TCO)		10.4	3.0	0.8
Annual serviceable seat-kilometers, M seat-km (40 flight-km stage length)		12	4	1
Cost per seat-km (CASK)[5] $USD M		0.77	0.75	0.56



What to watch out for in the next 12-18 months

First type certification from EASA and/or FAA

Production lines completed and ramping up

First commercial operations in China and the Western world

Vertiport installations gaining pace

First major players disappearing, either through acquisition or less formal absorption

We are publishing frequently on the future of aviation - join us for our next session!

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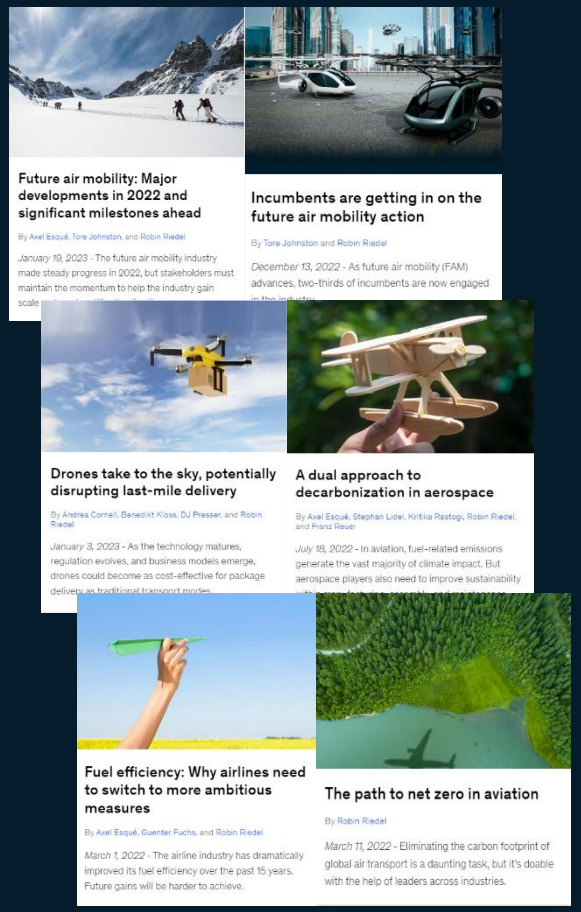

Reports and Presentations

Webinars

Thank you